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Peripheral arterial disease: Factors effecting utilization of ankle-brachial index

Justin Jaspers

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Justin Jaspers

Family Nurse Practitioner Graduate student

University of North Dakota

PERMISSION

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Department Nursing

Degree Master of Science

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Abstract

Background: Peripheral arterial disease (PAD) affects millions of individuals throughout the world, and significantly increases the risk of cardiovascular problems and death. Additionally, gout with elevated uric acid levels is an independent risk factor for developing PAD. A validated method to screen for PAD is ankle-brachial index (ABI). In clinical practice 44% of individuals with PAD are estimated to remain undiagnosed. PAD disease needs to be screened more readily and screening methods need to be standardized to improve diagnosis. ABI has been the screening method of choice to diagnose PAD and has proven useful in this regard. However, comorbidities like diabetes make the diagnosis of PAD more difficult with conventional ABI measurements.

Case Description: 46 year old male diagnosed with gout and past medical history of hypertension, dyslipidemia, and diabetes. Patient denies history of ABI testing for PAD. Patient's past medical history places him at increased risk for PAD.

Literature Review: Eleven studies were found and analyzed for relationship to factors affecting accuracy and utilization of ABI testing.

Clinical Relevance: Findings show that ABI testing has high specificity and sensitivity if completed correctly. This can be accomplished through education and training. Post-exercise ABI, toe-brachial index (TBI), and the lower of 2 ankle blood pressures compared to the higher brachial blood pressure, known as LABI method of measurements, may provide better accuracy and prognostic value when screening for PAD compared to conventional ABI. Additionally, oscillometric devices and Huntleigh Dopplex Ability may be an option for screening in primary care.

Background

A middle aged male presents clinically with symptoms consistent with gout. Upon conducting diagnostic testing, patient's laboratory findings conclude that patient has gout. The patient has a significant past medical history of diabetes type 2, hypertension, dyslipidemia, and kidney stones. Patient reports never having diagnostic testing for peripheral arterial disease (PAD) including ankle-brachial index (ABI) testing. Due to patient's past medical history patient has risk factors for PAD.

PAD is generally caused from the accumulation of plaque in the arteries of an individual and most commonly results from atherosclerosis (National Heart, Lung, and Blood Institute, 2016). This disease affects millions of individuals across the United States and is associated with smoking, diabetes, coronary heart disease, stroke, hypertension, hyperlipidemia, metabolic syndrome, and advanced age (National Heart, Lung, and Blood Institute, 2016). Worldwide this disease is highly prevalent, affecting around 202 million individuals (Chaudrua et al., 2016). Risk of mortality of individuals diagnosed with PAD within 10 years of diagnosis is 6 times greater than an individual without PAD (Tadej, 2013). Additionally, clinical presentation can differ significantly among individuals. In general, individuals with PAD who are 50 years of age or older present asymptomatically 20-50 percent of the time (Neschis & Golden, 2017). 40-50 percent of individuals present with atypical leg pain, 10-35 percent present with classic claudication, and 1-2 percent present with a threatened limb (Neschis & Golden, 2017).

Individuals with a diagnosis of gout are at an increased risk for vascular events (Clarson et al., 2014). Also, elevated serum uric acids levels are an independent risk factor for the development of vascular disease including PAD (Hjortnaes et al., 2007). However, screening individuals with gout for peripheral vascular disease including PAD is currently not considered to be best practice (Clarson et al., 2014). So, there is a need to use validated screening to assess a patient for PAD when risk

factors are present due to many individuals being asymptomatic in presentation. In clinical practice it is estimated that over 44% of individuals with PAD remain undiagnosed (Chaudrua et al., 2016). One validated method to screen for PAD is the ABI test. ABI is a non-invasive diagnostic tool that measures an individual's blood pressure in their arms and compares it to their blood pressure in their ankles (Centers for Disease Control and Prevention, 2016). In an individual that presents with atypical symptoms of PAD, if the ABI measurement is ≤0.9 it is considered diagnostic for PAD (Neschis & Golden, 2017). ABI measurement has high specificity and sensitivity provided the test is completed by a well-trained healthcare professional, and ABI is a very useful prognostic marker to assess an individual's overall and cardiovascular associated mortality (Chaudrua et al., 2016).

Case Report

History: A 46 year old well appearing man presents to the clinic with new onset erythema, slight swelling, and throbbing pain rated at a 6 on a scale from 0-10 in his right great toe starting 1 day ago. Patient denies any trauma or incident to explain his current pain in his right great toe. There is no prior history of trauma and patient has never experienced these symptoms in the past. No therapeutic interventions have been attempted by patient to relieve symptoms. Patient reports socially drinking 1-3 beers per week while attending curling club, otherwise denies tobacco and illicit drug use. Overall patient reports feeling well except for symptoms in his right great toe. There are no fevers, chills, night sweats, claudication, numbness, tingling, or loss of sensation associated with symptoms. Patient does have a significant past medical history of hypertension, dyslipidemia, diabetes mellitus type 2, and kidney stones. Patient denies prior history of peripheral vascular disease but also denies having diagnostic testing for this disease including ABI. Prior kidney stones were not evaluated for type per patient report.

Physical Exam/Diagnostic Findings: On physical examination patient is sitting upright on exam table in no acute distress. Cardiovascular examination reveals heart in regular rate and rhythm

with no clicks, gallops, murmur, or friction rub. The radial, dorsalis pedis, and posterior tibialis pulses are 2+ bilaterally with no peripheral edema noted to peripheral extremities. Capillary refill in upper and lower extremities is less than 3 seconds bilaterally.

Upon visualization of patient's lower extremities erythema localized to entire right great toe with no erythema noted beyond great toe. Minimal discomfort noted on plantar flexion, dorsiflexion, abduction, and adduction of right great toe. Slight swelling noted to right great toe with no open wounds, drainage, or significant warmth noted. Full sensation noted to dorsal, plantar, medial, and lateral aspects of bilateral lower extremities, and sharp and dull sensation normal in bilateral extremities.

Patient is afebrile at 37.4 degrees Celsius with a pulse rate of 72, respiratory rate of 16, and blood pressure of 126/78. Synovial fluid aspiration evaluation of metatarsolphalangeal joint of right great toe revealed rod-shaped crystals consistent with Monosodium Urate and 12,000 WBC. Also, serum uric acid level elevated at 10.9 and Erythrocyte Sedimentation Rate (ESR) elevated at 124. Evaluation of patient's complete blood count (CBC) and basic metabolic panel (BMP) are within normal limits.

Treatment Plan/Follow up: This patient's presentation and laboratory findings were consistent with a diagnosis of gout. Patient currently on a thiazide diuretic. Will hold patient's thiazide diuretic and educated patient to avoid alcohol and purine rich foods to reduce current symptoms and reduce the risk of future gout exacerbations. After discussion of treatment options with patient and due to patient's symptoms improving drastically since symptom onset, patient reporting symptoms as tolerable, symptoms not effecting his ability to complete daily tasks, and BMP unremarkable patient instructed to take 600mg of ibuprofen TID for 2-5 days until gout flare is controlled. Once symptoms are controlled, patient to taper off ibuprofen over the following 2 weeks after initial therapy. Patient to reduce dose by half after initial therapy for 5 days and to 1/4 original

dose for remaining 2 weeks with gout symptoms absent for at least 2 days prior to stopping NSAID therapy. Once current gout flare is completed and patient symptom free, this provider will consider starting allopurinol to reduce patient's uric acid levels to help prevent future gout attacks.

If patient's symptoms do not improve within 5 days patient is to return to clinic. If patient's pain increases, develops a wound over effected toe, erythema spreads from right great toe, or develops signs of infection patient to call provider immediately and come to clinic for reevaluation. If patient's redness does not improve or patient develops a wound patient may need to be assessed for peripheral vascular disease via ankle brachial index due to risk factors and past medical history of diabetes, dyslipidemia, and hypertension. Patient understands and agrees to treatment plan. Patient to call provider or return to clinic as needed with any other medical questions or concerns.

Literature Review

There is a need to ensure that PAD is assessed for and diagnosed correctly. A literature review was conducted utilizing CINAHL and Pub MED. These medical databases were searched for in the English language using terms such as "peripheral arterial disease diagnosis," "peripheral arterial disease screening," "ankle brachial index testing in peripheral arterial disease," "peripheral arterial disease AND diabetes," "peripheral arterial disease and TBI," "training ABI and peripheral arterial disease," and "peripheral arterial disease ABI AND training." The abstracts of the search findings were then reviewed. Throughout this process in reviewing literature available 11 studies were found to be suitable for the discussion of different types of diagnostic modalities for PAD, and the effect training and education has on diagnosing PAD.

Training and education

The screening method of choice for diagnosis of PAD involves ABI testing. This method of screening has traditionally been recommended by most scientific societies. ABI testing involves

taking only one blood pressure measurement in each of a patient's extremities to determine the ABI ratio (Real de Asúa, Puchades, García-Polo, & Suárez, 2012). This has been long thought to be the gold standard in screening for PAD. The correct technique to accurately complete ABI testing has traditionally involved the use of a doppler (Aboyans et al., 2008). The doppler is utilized to derive a ratio of blood pressures that is completed through comparing the higher of two systolic ankle blood pressure to the higher brachial blood pressure which is known as HABI (Jeevanantham et al., 2014).

Research studies have shown that there is a significant lack of uniformity in how individuals are trained to perform ABI whether it be differences in didactic, hands on, duration of training, or styles of training. Role modeling versus direct supervision provided for correct technique for ABI measurement is also a variation (Chaudrua et al., 2016). If ABI testing is not completed correctly the results are unreliable (Tadej, 2013). Furthermore, there is great variety in methods utilized to complete ABI tests including positioning of artery measured, measurement of blood pressure in arms, resting period for patient, and type of equipment used for ABI testing (Sihlangu & Bliss, 2012). Due to inconsistent training and performance of ABI, significant reliability concerns have been found with full doppler ultrasound ABI testing (Tadej, 2013).

Education has been proven to have great impact on reliability of ABI testing. However, there is great variability in the training process. For this purpose the literature was analyzed to better understand the value of formal versus informal education of those completing ABI testing. Sihlangu and Bliss (2012) conducted a study recognizing improvements in reliability with formal training. Training specifically included how to complete, measure, calculate, and interpret ABI tests. As ABI training progressed the quality and results obtained improved (Sihlangu & Bliss, 2012). These findings were further supported in Chaudrua et al.'s (2016) study. However, the highest correlation for improvement in ABI competency involved bedside training in a vascular laboratory in which trainees were exposed to multiple vascular cases, obtained practical guidance in conducting ABI

testing, and had the ability to practice ABI testing on real patients (Chaudrua et al., 2016). The cost of formal training is outweighed by more reliable ABI results and decreased disease burden. Therefore, it is recommended that all staff performing ABI testing should go through formal training.

In conclusion, there is a significant lack of uniformity and inconsistencies in clinical practice on how to correctly complete ABI testing. However, current studies support if ABI testing is done correctly it has high specificity and sensitivity for the diagnosis of PAD. Training programs and education have shown improvements in the measurement of ABI, correctly calculating ABI, and correctly interpreting ABI findings. Formal training with better standardization in correctly completing ABI testing can lead to improvements in diagnosing PAD and outcomes for patients.

Alternative Modalities in screening for PAD

Multiple studies assessed alternative methods of screening for PAD compared to the conventional method of ABI testing. One study completed by Jeevanantham et al. (2014), compared conventional ABI testing to an alternative form of ABI testing with the accuracy of both types of testing confirmed by angiography. Angiography is an invasive intervention that confirms the diagnosis of PAD, and angiography provides the clinician with information about the level of occlusion present in PAD (Jeevanantham et al., 2014). The alternative method utilized involved deriving the ABI ratio through using the lower of the two ankle blood pressures compared to the higher brachial blood pressure which is known as the LABI method (Jeevanantham et al., 2014). Findings showed the LABI method to have better sensitivity and accuracy compared to conventional ABI testing, and LABI had similar specificity to angiography to detect PAD in diabetics (Jeevanantham et al., 2014). Additionally, although both conventional ABI and LABI methods were shown to accurately detect above the knee PAD, LABI method was better able to predict below the knee PAD (Jeevanantham et al., 2014). Results showed that the LABI method had a higher sensitivity and overall accuracy to detect greater than 50 percent arterial occlusion of peripheral

arteries compared to conventional ABI testing (Jeevanantham et al., 2014). Furthermore, the LABI method was found to be more specific in predicting burden of PAD in participants (Jeevanantham et al., 2014). Thus the LABI method showed evidence of increased detection and better predicts PAD burden compared to conventional ABI testing. The LABI method is also more accurate in diagnosing PAD in diabetics and individuals with below the knee PAD.

Another study assessed the benefit of completing multiple blood pressure measurements in each of an individual's peripheral extremities. These measurements were compared to traditional ABI testing via one blood pressure measurement in an individual's peripheral extremities. This study was completed by Real de Asúa et al. (2012). The findings of this study conclude that one blood pressure in each extremity measurement is sufficient to confirm the diagnosis of PAD (Real de Asúa et al., 2012). In comparison to multiple blood pressure measurements in an individual's extremities, traditional method of ABI testing allows for a reduction in length of time needed to complete ABI testing. This reduces some limitations regarding time constraints in conducting ABI testing for PAD without affecting accuracy of results.

Variations of ABI testing and the overall accuracy of these alternative methods of ABI testing have also been investigated. In this study individuals were placed into groups with group 1 including individuals with normal resting (NR)/normal post-exercise (NE), group 2 NR/ AE (abnormal post-exercise), group 3 AR (abnormal resting)/ NE, and group 4 AR/AE (Hammad et al., 2015). This study found that individuals with AE ABI are at an increased risk for revascularization and all-cause mortality despite normal or abnormal resting ABI (Hammad et al., 2015). Additionally, post-exercise ABI measurements appear to provide greater prognostic information compared to normal or abnormal resting ABIs (Hammad et al., 2015). When keeping this concept in mind, post-exercise ABI may provide better diagnostic value for PAD in individuals that have a normal resting ABI but have significant risk factors for PAD.

All of these studies were reviewed to determine if there were alternative ways to screen for PAD which would improve its diagnosis. If there is an increase in diagnostic accuracy of tests utilized in screening for PAD, this can ultimately decrease the disease burden one may face through early intervention. The results of these studies show that to better ascertain whether or not an individual has PAD, LABI method and post-exercise ABI measurement may be better than conventional ABI measurement. The LABI method showed accuracy in screening routinely for PAD including individuals with diabetes, and this method provides better prognostic value (Jeevanantham et al., 2014). In addition, if there is high suspicion for PAD and traditional ABI testing done at rest is negative for PAD, post-exercise ABI testing may provide better diagnostic value in screening for PAD. Furthermore, abnormal post-exercise ABIs offer better prognostic and clinical value compared to normal or abnormal resting ABI (Hammad et al., 2015). Further studies could be completed regarding the use of LABI and post-exercise ABI methods, validating their accuracy, may change how routine screening for PAD is completed. In regards to obtaining multiple blood pressure measurements in an individual's extremities, there is no benefit over conventional ABI testing (Real de Asúa et al., 2012). Clinicians need to consider these factors when analyzing ABI results.

TBI versus ABI

Clinical guidelines recognize that ABI testing may be unreliable, and they recommend alternative tests such as TBI testing for individuals with falsely elevated ABI measurements (Stoekenbroek et al., 2015). Although TBI measurements are thought to be more accurate than ABI measurements when medial arterial calcification (MAC) is present, the relationship between TBI and ABI testing has not been well clarified (Watanabe et al., 2016).

When assessing for PAD, certain comorbidities have been thought to reduce the diagnostic accuracy of conventional ABI testing. Individuals who have long-standing diabetes, chronic kidney disease, or are receiving hemodialysis have been found to have a higher incidence of non-

compressible ankle arteries thought to be caused by severe MAC (Watanabe, Masaki, Kojima, & Tanemoto, 2016). Also, diabetes is a strong risk factor for PAD, and PAD has shown a strong association with poor outcomes in diabetics (Stoekenbroek, Ubbink, Reekers, & Koelemay, 2015). It is thought that the sensitivity of ABI testing is lower in some individuals due to the effect of MAC (Stoekenbroek et al., 2015). There is also an assumption that toe arteries are less susceptible to MAC which makes toe-brachial index (TBI) a better indicator of early PAD (Stoekenbroek et al., 2015). However, there is no consensus on which non-invasive screening method for PAD in diabetics is best (Brownrigg et al., 2016).

To assess the reliability of TBI testing compared to conventional ABI testing a research study was completed by Watanabe et al. (2016). This study was conducted to determine whether or not TBI testing is an acceptable alternative to conventional ABI testing in individuals where ABI testing is contraindicated. This study concluded that TBI testing in the great toe and second toe are acceptable alternatives to conventional ABI testing to screen for and diagnose an individual with PAD (Watanabe et al., 2016). The findings that TBI testing can be utilized instead of conventional ABI testing is supported in a study completed by Brownrigg et al. (2016). However, in this study the presence of diabetic neuropathy reduced the reliability of ABI measurements (Brownrigg et al., 2016). If TBI testing is negative this method of screening for PAD in diabetics regardless of presence of neuropathy is highly effective at ruling out disease (Brownrigg et al., 2016). Contrary to these results a study by Stoekenbroek et al. (2015) determined that diabetes does not alter ABI findings any greater than TBI findings in individuals with an ABI score of < 1.4. Additionally, there was no significant difference noted when comparing TBI and ABI measurements regardless of patient's diabetic status (Stoekenbroek et al., 2015).

Should ABI measurements not be appropriate for a patient with PAD, TBI measurements in either the individual's great toe or second toe are acceptable screening alternatives. However, there is

a lack of evidence to support that TBI testing is superior to ABI testing in early detection of PAD. If neuropathy is present in diabetics TBI testing may be a better screening tool for PAD compared to conventional ABI measurement. However, although much research has been conducted in regards to ABI testing and its impact on PAD, there is still conflicting evidence regarding TBI testing suggesting more research is still needed within this area. The inadequate research and conflicting evidence regarding the TBI method is likely another reason why consistent screening of PAD is lacking.

Screening in Primary Care

PAD has a significant impact on individuals and if it remains undiagnosed has the potential to lead to many problems. Individuals with PAD have an increased incidence of developing coronary artery disease and cerebrovascular disease that ultimately puts an individual at risk for a heart attack or stroke (Centers for Disease Control and Prevention, 2016). Also, due to the pathogenesis of PAD, atherosclerosis from fatty plaque buildup in an individual's legs can lead to limb ischemia. This disease process may cause a need to amputate portions of an individual's lower extremities. In clinical practice it is estimated that over 44% of individuals with PAD remain undiagnosed (Chaudrua et al., 2016). In general, individuals with PAD who are 50 years of age or older present asymptomatically 20-50 percent of the time (Neschis & Golden, 2017). This warrants increased screening for PAD.

Multiple methods have been researched and tested to reduce the disparity of screening and improve diagnosing individuals with PAD. Primary care is a great place to implement methods of screening for PAD to catch the disease early. This can lead to better optimization of treatments for this disease and help to limit its effect on an individual. However, in primary care there continues to be a significant amount of individuals who do not receive screening for PAD that are at risk for this disease.

Many of these methods compared the utilization of automatic blood pressure devices to traditional ABI testing, and palpation of pulses compared to doppler acquisition of pulses. This was done because in primary care, oscillometric measurement via standard automatic blood pressure machine is very quick and easy to use (Nelson et al., 2012). Also, according to Sihlangu and Bliss (2012), the idea behind completing ABI testing via palpation of pulses is that it may limit the need for education on how to correctly utilize a doppler device.

In a study completed by Aboyans et al. (2008), the accuracy of ABI testing done via palpating peripheral pulses was compared to traditional ABI testing with doppler device. Findings indicate that ABI testing done via palpation of peripheral pulses provided good sensitivity but poor specificity (Aboyans et al., 2008). Also, the level of reproducibility via palpation of pulses was poor compared to traditional doppler ABI testing (Aboyans et al., 2008). In another study by Sihlangu and Bliss (2012), the utilization of a doppler device, compared to palpation of peripheral pulses, led to an improvement in diagnostic accuracy of ABI testing. These findings conclude that obtaining ABI test results by palpation of pulses, compared to doppler, is not a reliable and adequate substitution for conventional ABI testing.

ABI testing completed via automatic blood pressure device, as compared to conventional ABI, was more specific than sensitive (Aboyans et al., 2008). These findings were supported by Nelson et al. (2012). ABI testing via automatic blood pressure device yielded 92% specificity, 90% negative predictive value, 84% accuracy, and 62% sensitivity (Nelson et al., 2012). When looking at the sensitivity of ABI testing using automatic blood pressure devices there is little value in using this method to confirm PAD. However, the high specificity and negative predictive value of ABI testing via automatic blood pressure devices has good screening value in ruling out PAD.

Another method in screening for PAD was analyzed called the automatic Huntleigh Dopplex Ability device. This device was created to aid in reducing time of ABI testing, ease of calculating

results, and reduction in extensive training in full doppler ultrasound ABI testing (Tadej, 2013). The test is capable of calculating ABIs in 3 minutes and does not require that the patient be resting for the test to be completed (Tadej, 2013). Additionally, the Huntleigh Dopplex Ability device automatically calculates, interprets, and displays pulse volume waveforms for the healthcare professional (Tadej, 2013). The lack of needing to educate individuals in correct use of a doppler device, ease of completing ABI testing, and reduction in time may aid in more individuals being screened for PAD. This could lead to earlier diagnosis due to fewer limitations in screening for PAD.

The reliability and accuracy of Huntleigh Dopplex Ability device was assessed compared to conventional doppler based ABI testing in a study by Tadej (2013). When comparing results from Dopplex Ability completed unrested, Dopplex Ability completed at rest, and conventional doppler ABI testing at rest, results were promising. These results showed a good correlational in the ability of Huntleigh Dopplex Ability device to provide accurate and reliable test results (Tadej, 2013). Findings in this study regarding the use of the Huntleigh Dopplex Ability device can ultimately lead to an increase in PAD diagnosis that is quick, user friendly, accurate, and reliable. This device is something that many primary care settings may find attractive and allows for a more streamline approach to PAD screening.

These studies conclude that to increase the amount of screening completed for PAD the use of the Huntleigh Dopplex Ability device may be an option, and ABI testing done by automatic blood pressure devices in patients at high risk for PAD may be a suitable option in primary care to rule out PAD. However, utilizing an automatic blood pressure device method should not replace conventional ABI testing for routine diagnosis. Additionally, the acquisition of ABI test results via palpation of pulses, compared to doppler, is not a reliable method of screening for PAD. This method of screening for PAD should not replace conventional ABI testing in primary care. Therefore, primary care

clinicians should continue to utilize conventional ABI testing until further research is able to support the automatic blood pressure device method.

Conclusion

In conclusion, regardless of the method of screening for PAD performed, standardized training and education on how to appropriately perform ABI testing can significantly increase the diagnostic quality and accuracy of PAD screening. Methods including LABI and post-exercise ABI testing may provide better diagnostic and prognostic value in screening and diagnosing PAD compared to conventional ABI testing. Alternative methods such as TBI testing can be used in place of ABI testing if unable to complete ABI method of screening for PAD due to contraindications or limitations in conducting ABI measurements. However, more research and evidence needs to be conducted to determine whether TBI testing is a better method of screening for PAD compared to conventional ABI testing. To increase the ease and limit possible deterrents in screening for PAD such as time constraints, Huntleigh Dopplex Ability, and ABI testing utilization of automatic blood pressure devices in patients at high risk for PAD may be an appropriate alternative to conventional ABI testing. However, ABI measurement via automatic blood pressure devices should not replace conventional ABI testing for routine diagnosis. Furthermore, although much research has been conducted in regards to ABIs and its impact on PAD, there is still conflicting evidence suggesting more research is still needed within this area. The conflicting evidence is likely a barrier for consistent ABI screening for at risk PAD individuals. Furthering the evidence on these topics hopefully can create a more streamline approach to screening and diagnosing PAD.

Learning Points

- Standardized training and education significantly improves diagnostic accuracy of ABI testing and screening for PAD.

- LABI and post-exercise ABI testing may provide better diagnostic and prognostic value compared to traditional ABI testing.
- TBI testing can be utilized in place of traditional ABI testing if contraindications are present for ABI testing, but more research is needed to determine its superiority over ABI testing in diabetic patients.
- In an effort to improve screening for PAD Huntleigh Dopplex Ability and ABI testing via automatic blood pressure device may be appropriate, but ABI testing via automatic blood pressure device should not replace traditional ABI testing for routine diagnosis of PAD.
- Due to the conflicting evidence and lack of clear cut guidelines regarding PAD screening methods, clinicians in primary care settings are not consistently screening high risk patient populations.

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